MODIS DATA SYSTEM STUDY

TEAM PRESENTATION

August 5, 1988

AGENDA

1. Level-1 Data Requirements
2. Level-1 Processing Operations Concept
3. Downlink Data Structures and Availability (Response to Action Item 7/29-2)
4. Traceability to NBS Standards for MODIS Visible and Thermal Channels
5. MIDACC Operations Concept
6. Suggested Revisions to the Functional Requirements Outline
7. Action Items

LEVEL-1 DATA PRODUCTS REQUIREMENTS

These requirements are presented for review. They contain assumptions which may be changed as the overall requirements of the MODIS Information, Data, and Control Center (MIDACC) are refined and additional requirements are identified. Further development of the higher-level processing requirements will enable these requirements to be stated more precisely.

1. The level 1 processor shall have the capacity to process 24 hours of playback data within 8 hours of the next 24 hour period.

2. The level 1 processor shall also be capable of performing reprocessing, special requests, near-real-time, and backlog processing, in addition to the standard processing of playback data.

3. There will be two types of level 1 products, namely level 1A and level 1B products.

4. Until reversibility of the calibration process is demonstrated, it is assumed that all of the level 0 data will be processed to level 1A and level 1B, and that both 1A and 1B products will be archived.

5. There will be separate MODIS-N and MODIS-T level 1 A products.

6. There will be separate MODIS-N and MODIS-T level 1B products and certain other standard level 1B products which may consist of combinations of selected MODIS-N and MODIS-T channels.

7. Level 1 products shall contain all of the information necessary for the creation of catalogs and inventories of level 1 data, and this information should be passed on to the next level of processing.

8. The basic level 1 product time span is TBD, but may be multiday, daily, orbital, divided by fraction of a day, etc.

9. The level 1 processor will receive level 0 data in a form that is sequenced by time, by focal plane, by along-track distance, and by band configuration along the scan direction. The level 0 data will be transmission error corrected or flagged, have redundancies removed, and be appended with ancillary data.

10. The level 0 data shall contain:

- Instrument science data in the form of digital counts
- Calibration target data taken at most once per scan
- Time and spacecraft ephemeris
- Spacecraft attitude and/or instrument attitude

- o Platform engineering data
- o Instrument engineering data
- o Other ancillary data (e.g., land/ocean flag)

11. Most of the level 0 data are 12 bits in length and packed.

12. The inputs to the level 1 processor will include:

    - o level 0 data
    - o Spacecraft ephemeris data and attitude data from the backup system
    - o Other ancillary data (e.g., CIA world map)

13. The word size for the level 1 data products is TBD.

14. Data compression on-board the POP or on the ground is TBD.

15. The level 1 processor shall organize the science data into logical data records that are TBD. The natural blocking of the MODIS data is by observation swath (scan) (64 km x 1780 km for MODIS-T and 8 km x 1780 km for MODIS-N). Note that calibration reference data are taken, at most, once per swath. The requirement of putting one full swath into the memory of a processor may be too stringent for many users. It is anticipated that a strategy will be developed to break swaths into smaller scan segments. Any segmentation strategy should have the following characteristics:

    - o Each segment should be preceded by a segment description header.
    - o Each segment should be made as complete as possible in terms of Earth location and calibration of the pixels.
    - o Segmentation should facilitate the next level of processing.

16. The organization of the level 1A and 1B data within a swath shall be spectral channel sequential (i.e., sequential pixels in all scan lines within a swath shall be from the same channel).

17. The level 1A data product shall contain the level 0 counts of the sensor, ancillary, and housekeeping data.

18. The level 1B data product shall be, to the greatest extent possible, identical in format to that of level 1A; however, in the level 1B data the radiometric calibration shall be applied to the sensor units, and Earth location computations shall be applied at the anchor points.

19. The level 1A and 1B data products shall have appended to the various levels of data organization (from the basic product length to the lowest level of segmentation) subsets of the following ancillary data (at the appropriate resolutions in time and space):

- o MODIS-N/MODIS-T sensor identification
- o Product sequence number/version number
- o Processing date
- o Calibration algorithm identification number/version number
- o Product start and stop times
- o Orbit number(s)
- o Geographical boundaries of the product
- o Channel identification
- o Data quality flags
- o Calibration quality flags
- o Housekeeping data
- o Engineering data
- o Land ocean flags
- o Measure of cloudiness
- o Instrument tilt information (MODIS-T)
- o Scan number(s)
- o Attitude information
- o Platform ephemeris
- o Time code
- o Solar and satellite zenith angle information
- o GPS time correction
- o Platform structure telemetry
- o Calibration coefficients(level 1B)

20. There shall be separate calibration level 1A and 1B data products which will consist of data taken during calibration modes (i.e., when the sensor views the diffuser plate, calibration blackbodies, etc.).

LEVEL 1 PROCESSING OPERATIONS CONCEPT

MODIS level 1 data processing takes place in the CDHF, and involves the transformation of level 0 data received from the DHC into level 1A and 1B data products. The level 1 processing operations concept presented below is based upon the LEVEL 1 DATA PRODUCT REQUIREMENTS.

1.0 Level 1A Processing

There are 4 basic processing steps in the processing of level 0 data to produce the level 1A product. The first is the reorganization of the sensor data into a structure that expedites efficient remapping and resampling algorithms in the next level of processing. The second processing step is to append georeferencing information, and calibration parameters or tables. Third, header record information are generated to facilitate cataloging and data extraction. Finally, after processing is completed the data are repacked from the 16-bit word structure into the 12-bit word structured in order to minimize the volume of the level 1A data set. Each of these processing steps is discussed below.

1.1 Data Record Structure

As stated in the Level 1 Data Products Requirements, the basic level 1 product length and the logical data record structure are TBD. However, it is clear that at the higher levels of processing, the need to remap and resample data implies that the sensor data be arranged in channel-sequential order (i.e., with sequential pixels in a scan line from the same channel).

Also, for purposes of forming images, the optimum data record structure should be based upon the scan of the instrument. A natural organization of the data would be to define the logical data record as the amount of data observed in one scan of the instrument arranged as complete swaths, one for each spectral channel. The resulting logical data record volumes would be quite large, and smaller computing systems might have trouble ingesting and operating on such logical data records.

It is conceivable that a hierarchy of logical data records could be created within the level 1A and 1B products so that the large volume logical data record could be input to large capacity processors such as will be used in the CDHF, and smaller logical data record lengths could be input into mini- and micro-computers for processing and analysis. Such a hierarchy might be defined such that the largest logical data record would be one complete scan as mentioned above. Smaller data record structures could then be defined as segments of a scan.

The level 1A processing software will reorder the level 0 data to that of channel sequential pixels for each scan. Limit checking will also be performed at this step in the processing. The degree of segmentation that will form the smaller logical data records is TBD.

Converting the level 1A data from 10- or 12-bit words originating from the instrument into 16-bit words will be performed during the reformatting step only if the 1A data are to be input to the level 1B processing step before being sent to the archive.

1.2 Level 1A Appendix Information

Raw georeferencing and time information including spacecraft ephemeris, spacecraft attitude, instrument pointing (MODIS-T), time code, and GPS time correction will be appended to the level 1A data with the minimum processing required for spatial and temporal cataloging of the level 1A data. This will require conversion of the platform time code into universal time to give the start and stop times at least at the level of the largest logical data record. Similarly, Earth location calculations need to be performed for portions of each largest logical data record (e.g., the locations of a corner of each swath could be calculated). This information will then be appended to the largest logical data record to provide start and stop times and geographic coverage to users of level 1A data.

Appended to each swath of data, in the form of raw counts, will be the sensor calibration observations, calibration target temperatures, lamp currents, etc., and other ancillary data, such as instrument housing temperatures, relevant to radiometric calibration. No further processing of these data will occur at this point.

1.3 Header Record Information Generation

All of the information necessary for cataloging and data extraction will be computed and inserted in the headers. (See the Level 1 Data Products Requirements.)

1.4 Repacking of Level 1A Data

Level 1A data which have been converted to 16-bit word size will be repacked to the original 10- or 12- bit word size to reduce the volume of data that must be archived.

2.0 Level 1B Processing

To the extent possible, the level 1A data structure will be preserved in the level 1B products. The basic level 1B processing steps described below are: Earth location and zenith angle and time calculations; radiometric calibration; data quality assessment; header record processing; and repacking.

2.1 Earth Location and Zenith Angle Calculations

Earth latitude, longitude, solar and instrument zenith angles will be calculated using the attitude and ephemeris data on the level 1A product. These calculations will be performed only at selected anchor points to produce a sparse lattice of points which cover each swath of observations in order to reduce the computation requirement. The Earth location, and zenith angles of all other pixels in the swath will be determined by interpolation between [illegible]

Initial analyses indicate that it may be possible to perform the direct calculations for about 10 pixels in only one out of every 50 or 100 scan lines and still achieve the desired level of accuracy.

2.2 Radiometric Calibration

The basic method used to radiometrically calibrate the raw detector output data involves the application of a calibration equation derived from the periodically scheduled calibration observations. This yields a new pixel value that represents the physical value ,i.e., radiance or intensity, observed by the instrument. The constants in this equation are determined by commanding the instrument to look at calibration targets of known intensity.

A calibration equation will be required for every spectral channel for each scan line detector. Thus, for MODIS-N, (30 x 8 +8 x 32 + 2 x 128) = 752 equations will be required, and 64 x 64 = 4096 equations will be required for MODIS-T. These equations must be applied to every pixel of observed data. Since the sun, through a diffuser plate or integration sphere, will likely be the principal calibration source for the visible and near infrared channels, the calibration observations for these channels will be made, at most once per orbit, as the spacecraft passes the terminator. On the other hand the thermal infrared channel calibration observations will use an internal calibration target which can be viewed during each scan cycle of the instrument. Both types of channels will make use of periodic space looks which could be performed as often as once each scan. The calibration constants will be determined by using appropriate averages or samples of these calibration observations.

The data processing steps for radiometric calibration consist of selecting the samples from the calibration observation data that provide a full solar or thermal target view, performing noise screening to reject noisy observations, and applying the calibration equation to every pixel in one or more swaths of data. Target observations must be converted into values of intensity that are, to the highest accuracy possible, traceable to known intensity standards. In the case of the solar calibration observations, seasonal trends in observed solar intensity due to beta angle changes and changes in the distance to the sun, must be removed to provide normalized calibration intensities. The thermal calibration targets are monitored by a number of temperature sensors. Here, data processing must be performed to convert the temperature sensor voltages into a calibration target temperature which permits the calculation of the calibration radiance.

The calibration process will be monitored by members of the MODIS Science Team who will examine long-term trends in instrument response, calibration target characteristics, etc. This may result in improved calibration algorithms or modifications to the calibration constants to remove trends in instrument response and or calibration target output. Implementation of these new algorithms or constants will necessitate delaying the level 1B production process, or require reprocessing of the level 1B data.

2.3 Data Quality Assessment

Part of the level 1B processing will include overall data quality control, and the resulting statistics will be appended to the level 1B data.

2.4 Header Record Processing

All of the information necessary to access and retrieve the data will be placed in the header records. See the Level 1 Data Product Requirements.

2.5 Repacking of Level 1B Data

Level 1B data which have been converted to 16-bit word size will be repacked to the original 10- or 12- bit word size to reduce the volume of data that must be archived.

3.0 Reprocessing

Reprocessing of level 1 will necessitate reprocessing of all higher level products.

3.1 Level 1A Reprocessing

Reprocessing of level 1A data will be necessary if improved values of the basic telemetered information from the instrument or spacecraft are provided. The reprocessing will consist of replacing the values in the current version of 1A with the improved counts, and updating the header information.

3.2 Level 1B Reprocessing

As discussed above in section 2.2, reprocessing of level 1B data will be required when new calibration algorithms and/or calibration constants are identified by the Science Team. New intensity or radiance values will be calculated, and the header data and documentation will be updated.

Downlink Data Structures and Data Availability

Data Structures

The Consultative Committee for Space Data Systems (CCSDS) defines two types of data transfer blocks that facilitate the transfer of instrument data from an orbiting platform to the appropriate ground facility. One type of data block is known as a Source Packet or "packet" and is uniquely associated with a specific onboard instrument. A second and more general type of data block is known as a Transfer Frame or Virtual Channel Data Unit ("VCDU") and it facilitates the communication of all data transferred to the ground using the space data link.

The basic structure of a Source Packet or "packet" is shown in Figure 1. A primary header is always required; it contains basic identification or addressing information for the packet, sequence control information for long packets that have been broken into shorter segments to facilitate communication, and a packet length indicator. If the user desires, a secondary header may be defined to further specify the nature or routing of the data that is to follow. The CCSDS has not presently defined a standard format for the secondary header, so this item can be structured as the user desires. Error control coding for packets is also not specifically defined, so the user may include or omit such coding as he desires. The type and rate of coding that may be used is also left to the discretion of the user.

The generation of acceptable instrument data packets is the responsibility of the individual instrument-unique data processing systems that support the individual instruments. On the ground, packet address information is used by the Data Handling Center function to route the individual packets to the appropriate instrument data systems, but otherwise the interpretation of packet information on the ground is the responsibility of the instrument-unique portions of the data system.

The CCSDS also defines a second type of Source Packet with modified header fields to support segmentation of long packets as shown in Figure 2. This format differs from the Version 1 format in the Packet Sequence Count field and the Segment Length field. In this format, the Packet Sequence Count is not incremented for each message segment, but is unique to the original instrument data block before segmentation is applied. Also, the segment length indicator indicates the length of that portion of the original message that remains to be transmitted rather than the length of the original message.

The structure of a Transfer Frame or "VCDU" is indicated in Figure 3. The use of Reed-Solomon coding is strongly encouraged although options exist that use other codes or no error correcting code at all. The structure of the primary and optional secondary header is indicated in Figure 4. The optional Transfer Frame Trailer provides a location for an Operational Control Field or

Frame Error Control Word that may be desirable in certain applications.

Data Availability

The Customer Data and Operations System (CDOS) provides two processing facilities where downlinked data may be available: the Data Interface Facility (DIF) and the Data Handling Center (DHC). The DIF provides the initial interface for data received on the space downlink. Operating at data rates up to 300 Mbps, and without delaying the data, the DIF decodes the address information in each transfer frame and routes the data to the appropriate location for further processing. All MODIS data will be routed to the DHC at GSFC. The DIF also provides temporary storage of all incoming data to allow retransmission, should data losses occur during transmission to the next data handling station.

The DHC completes the processing of the received data stream to recreate the individual Source Packets generated by the platform processing system. Standard processing functions include:

(1) the correction of errors in received data transfer frames, if possible.

(2) the processing of Transfer Frames to eliminate duplicates and correct reversed frames.

(3) the conversion of Transfer Frames into constituent Source Packets including the reassembly of any Source Packets that were segmented during the generation of Transfer Frames.

(4) the provision of platform-level and EosDIS ancillary data of common use to all payload instruments.

In the standard processing mode, the generation of DHC output products must await the receipt of complete data sets from the satellite data system. Because of uncertainties associated with the operation of the onboard tape recorders and the data transfer system, required Transfer Frames may not be transmitted on the first attempts, and the guaranteed availability of routine data sets is within 24 hours.

Besides the routine production mode, the DHC provide two special modes with earlier data availability. Real time data transmissions from the satellite may be processed and made available at the DHC in real time. This mode avoids the uncertainties and complexities introduced by the operation of the onboard tape recorder. All Transfer Frame processing has been done and data is routed to the appropriate instrument data system as described above.

A second option is the Priority Playback Mode. In this mode, data is recorded on the onboard recorder but is processed at the DHC in real time as the data becomes available. Two options are available. The user may request to receive data directly as the data segments become available without waiting for a complete data set to arrive from the satellite. In this case, the user is responsible for assessing and assuring the completeness of data sets. Or the user may request that only complete data sets be made available after all data segments have been received. Operation in this mode may involve delays nearly equal to those in the routine processing mode, since the primary source of delay in the routine mode is the arrival of complete data sets. This mode differs from the routine mode in that the processing capabilities of the DHC are made immediately available without the necessity for data to wait in a processing que.

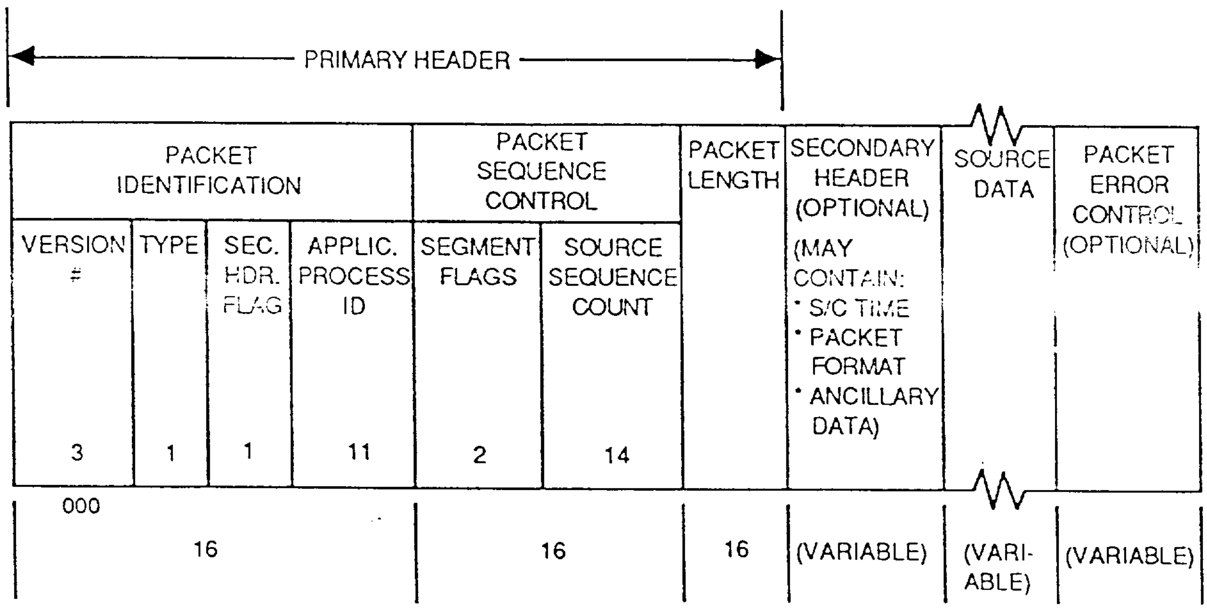


Figure 1 Version 1 "Source Packet" Format

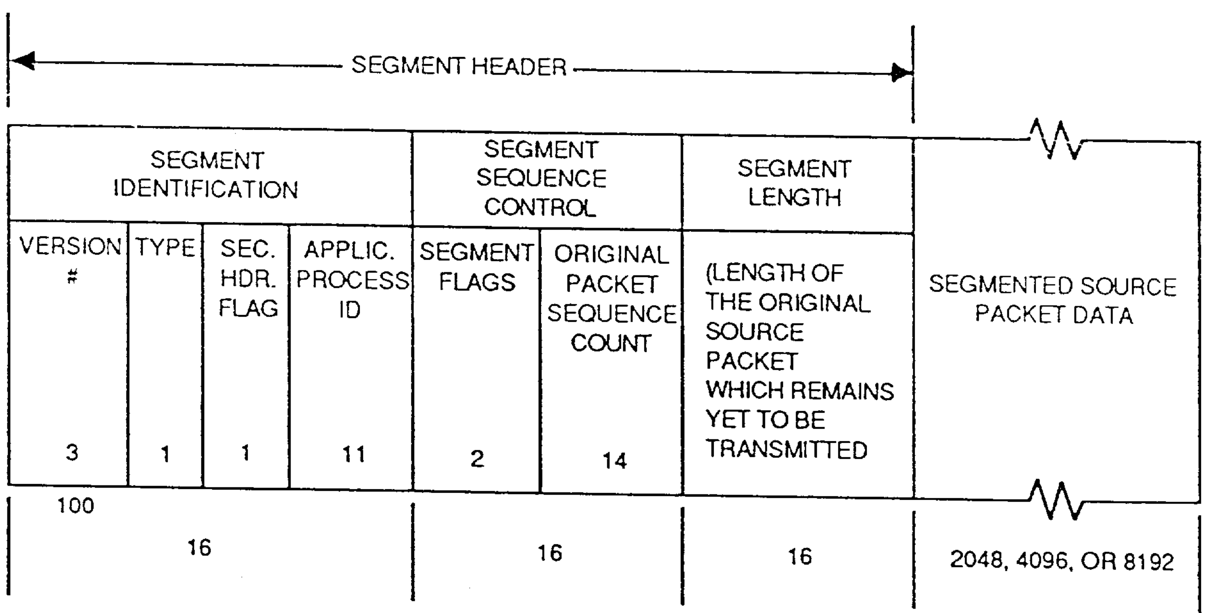


Figure 2 Version 2 "Telemetry Segment" Format

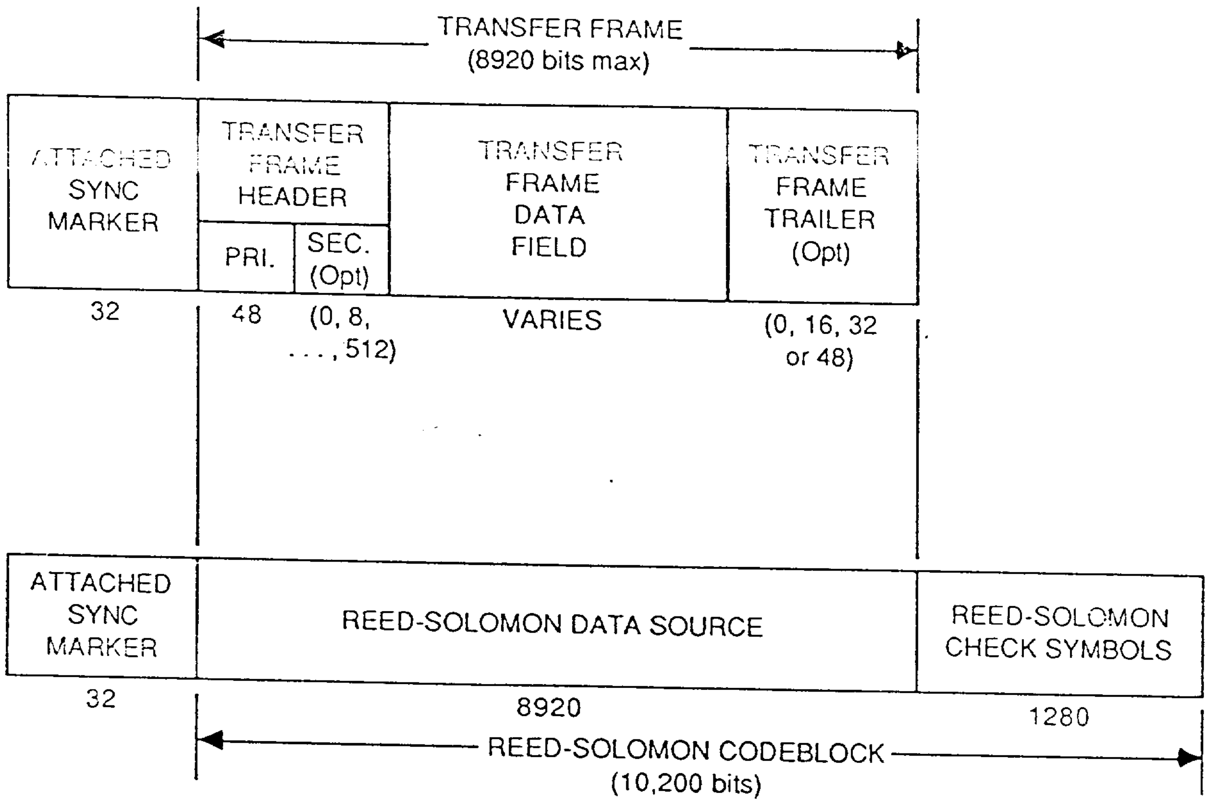


Figure 3 Composite Version 1 Transfer Frame/ Reed-Solomon Codeblock Format

40 | 8920
223
40 | 1280

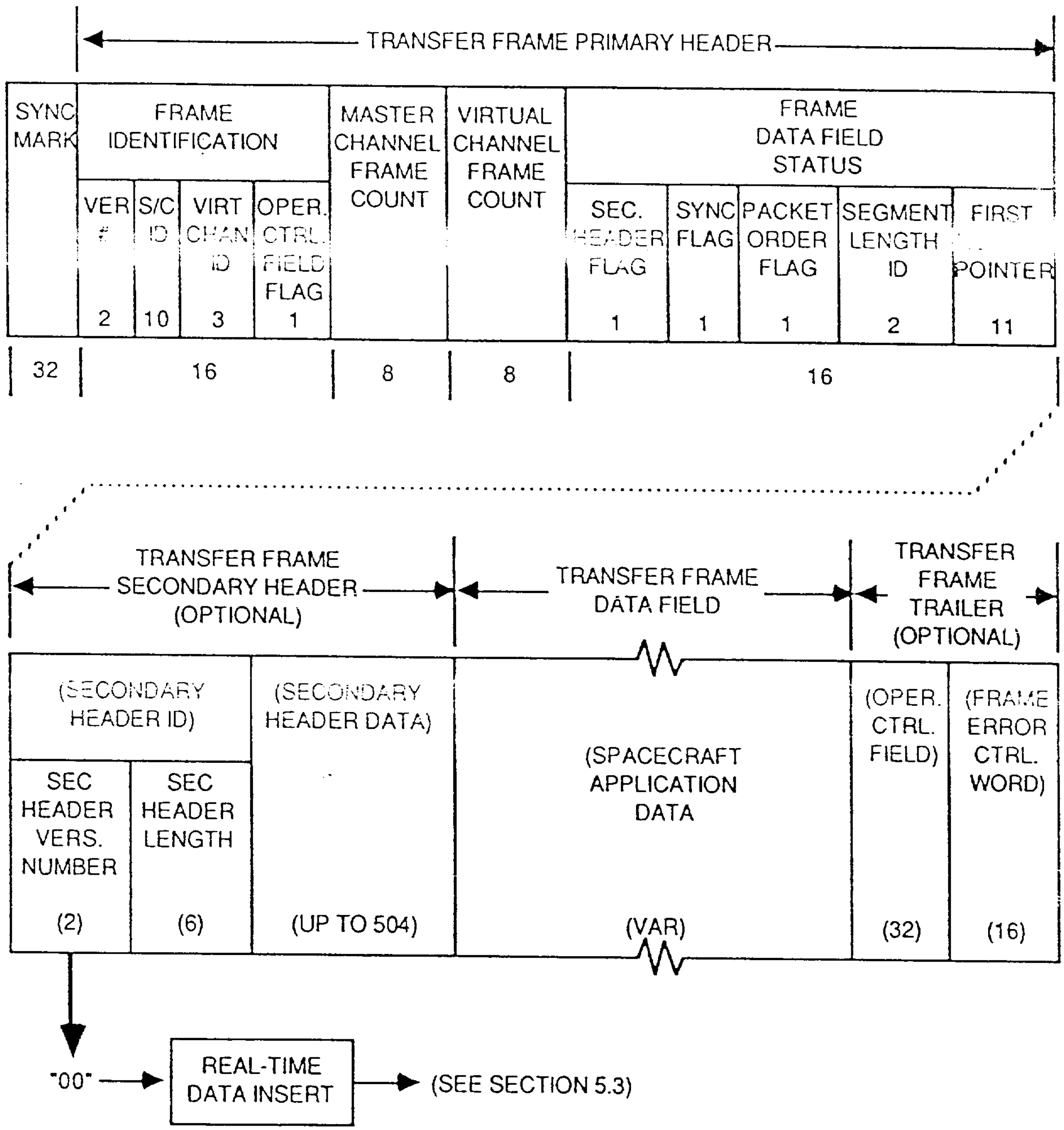
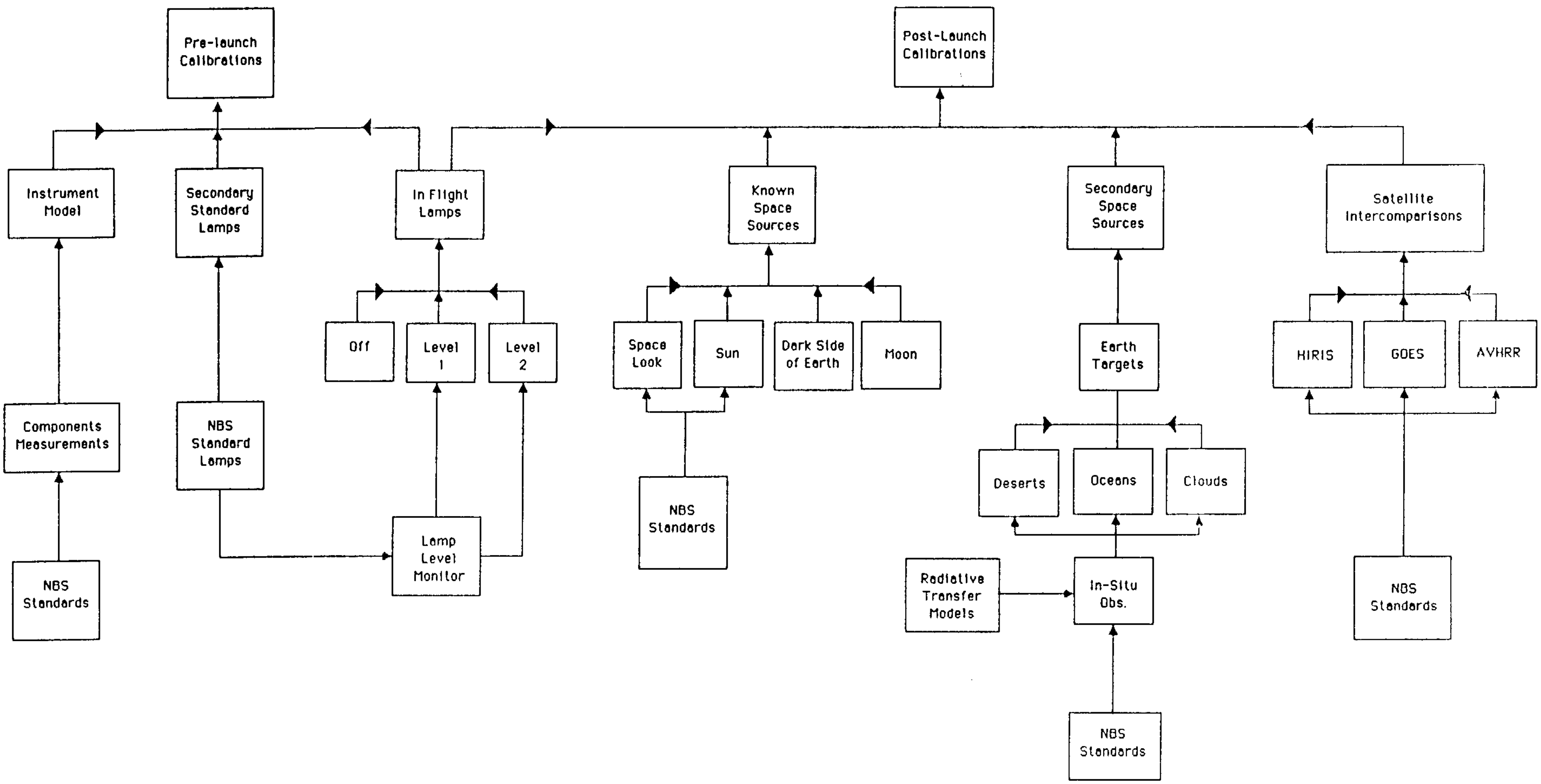
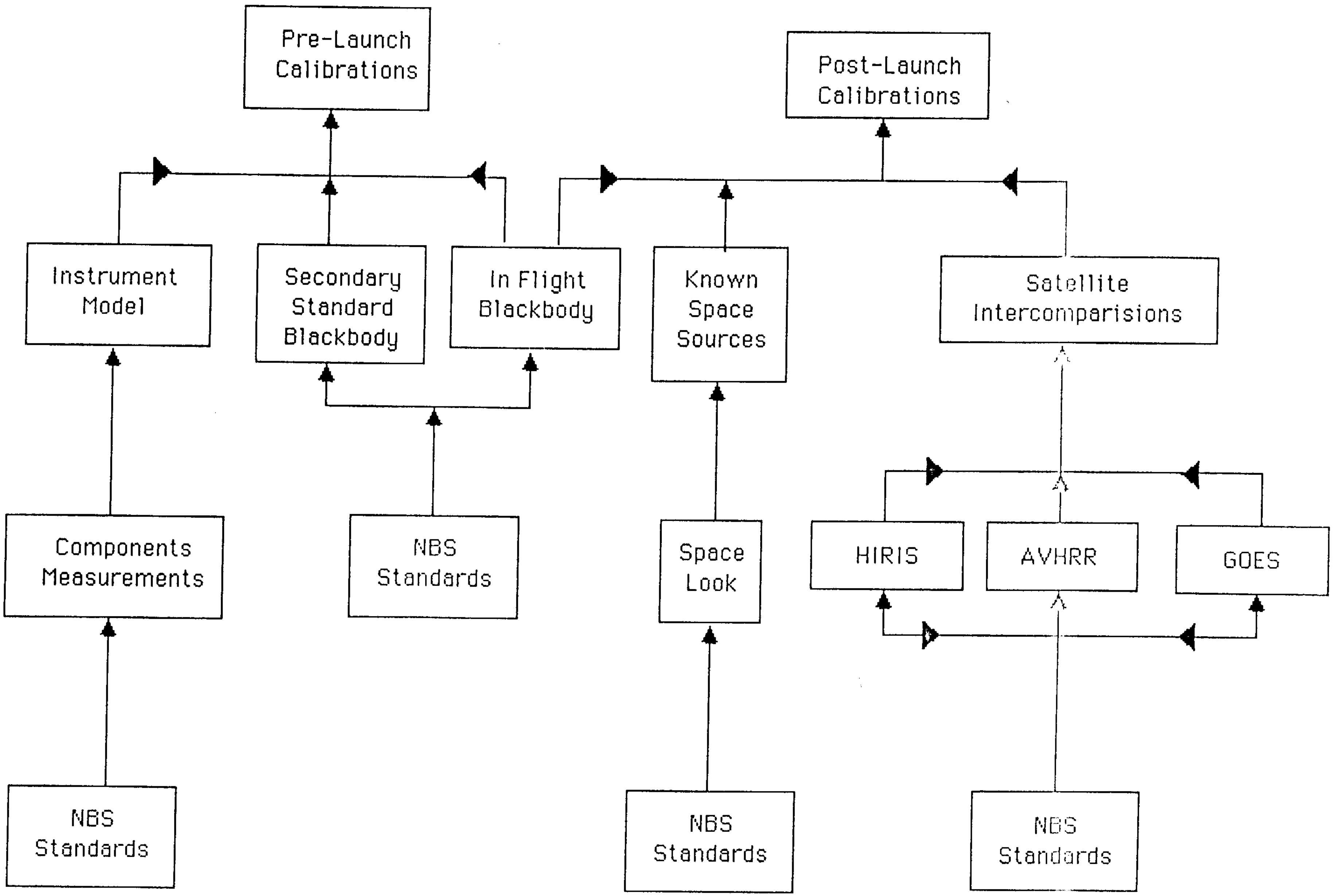


Figure 4 Version 1 Transfer Frame Header Format

Traceability to NBS Standards For MODIS Visible Channels



Traceability to NBS Standards for MODIS Thermal Channels



A MIDACC OPERATIONS CONCEPT

1.0 THE MIDACC OPERATING ENVIRONMENT

This MODIS Information Data and Control Center (MIDACC) Operations Concept is derived from the information contained in Section 5 of the EosDIS Baseline Report. As an EosDIS unique element, the MIDACC must sustain and maintain the command and control of the MODIS instrument and the routine production of scientific products derived from its data. The routine production of MODIS data products must support an overall, coordinated scientific plan for the Eos program. The development and maintenance of this plan is the responsibility of various working groups whose roles will be briefly described below (please see the Baseline Report for full details).

1.1 PROGRAMMATIC COORDINATION

The International Coordination Working Group (ICWG) will provide programmatic coordination of high-level policy and science consultation and guidance for the international Eos mission on all science-related long-range mission objectives. It will consist of one to three representatives from each of the major Eos partners. It will recommend payload responsibility and platform assignment for Eos, and it may also: establish overall objectives, assist in developing scientific requirements, assist in definition of international scientific platform data interfaces, and participate in the Eos project reviews to coordinate scientific requirements and mission decisions relating to international scientific objectives. It is anticipated that this group will meet infrequently.

1.2 SCIENCE ORGANIZATIONS

1.2.1 International Investigator Working Group (IIWG)

The organization of the international scientific efforts of Eos is centered around the International Investigator Working Group (IIWG), formed to coordinate research and operations among the Eos Space Station Polar Platforms.

The IIWG is the primary science element of the international Eos mission and will formulate the international observing policy and overall science objectives for all Eos platform activities. They will also develop science plans to accommodate special windows of opportunity. The IIWG will be divided into four subgroups (Investigator Working Groups), one for each platform. The IIWG will meet once a year during operations to discuss the scientific results of the mission and review and coordinate future investigations and related observational sequences.

1.2.2 Investigator Working Group (IWG)

There will be an Investigator Working Group (IWG) for each of the Space Station Polar Platforms (2-NASA, 1 each for ESA and Japan). The NASA IWGs are the primary science elements of the NASA Eos Project. The play the leading role in the overall optimization of the science return from the two U.S. afternoon platforms. These activities are coordinated with the IIWG. The NASA IWGs are composed of the following members:

- Eos Project Scientist (Chairman)
- Principal Investigators from that platform
- Team Leaders from that platform
- Program/Deputy Program Scientist (ex officio)

The IWG receives policy, guidelines, and overall science objectives from the International Investigator Working Group (IIWG). The IWG will provide high-level science mission guidance to the Eos Project, establish science mission priorities and develop the long term detailed science plan (updated as required), and evaluate proposals for data observations submitted to the Science Operations Team. The IWG will meet on a regular basis for exchange of inter-experiment information, coordination of investigations, review of requests for specific observational sequences, and review of scientific results of the mission. It is the MODIS Team Leader, a member of the IWG, who provides the science plan and coordinated MODIS observation requests to the MIDACC for planning and scheduling.

1.3 MODIS INSTRUMENT TEAM

The MODIS Instrument Team consists of selected scientists who are interested in investigations which make use of the MODIS Research Facility Instrument being developed by the Eos Project.

The Team will consist of Team Members (TM) and will be organized under the direction of a Team Leader (TL). The Team will plan and conduct investigations, participate in final instrument definition, development, test, calibration and operation, and develop algorithms for the reduction, analysis, and interpretation of the data, and publish results. The Team will have access to the Instrument Support Terminal (IST) of the MIDACC from which to participate in instrument planning and scheduling, instrument monitoring and problem resolution. The Team will also have available the Team Member Computing Facility (TMCF) of the MIDACC from which to develop and test algorithms, analyze MODIS data, and produce data sets.

1.4 OPERATIONS TEAMS

1.4.1 Platform Operations Group

The Platform Operations Group is responsible for the operation of all U.S. platforms, including their core systems. The Platform Operations Group, though not under Eos Project control, will function in the Platform Support Center (PSC) under a Mission Operations Manager (MOM). The MOM in the PSC will work closely with the EosDIS MOM to meet mission requirements. The Platform Operations Team assigned to Eos will coordinate with the EosDIS Mission Operations Team to resolve conflicts in the mission schedule. The Platform Operations Group will provide the EMOC with a schedule of the available platform core resources. The group will also coordinate schedules for TDRSS, NASCOM, and other network resources required to support Eos. During operations, the Platform Operations Group will monitor payload use of platform resources. If the use exceeds the allocation, the group will coordinate action with the EMOC.

1.4.2 Flight Operations Group

The Eos Flight Operations Group will be composed of three teams of Eos-dedicated personnel responsible for mission operations and instrument management. These teams--the Science Operations Team, Mission Operations Team, and Instrument Management Team--will report to the EosDIS Mission Operations Manager (MOM) who is responsible for the safe accomplishment of EosDIS mission goals. The MOM will report on the Eos operations to the Eos project and to the IWG.

1.4.2.1 Science Operations Team

The Science Operations Team will be composed of the following members:

- o Assistant Project Scientists (APS)
- o Specialized personnel (analysts selected to assist with the off-line planning and scheduling

The APSs have the functional responsibility of coordinating science plans. The APSs report to the Project Scientist on the IWG and the Project Operations Director (POD) on matters concerning mission operations. Most conflicts for Eos instruments usage will be resolved by the APSs. The POD will resolve major conflicts, including conflicts with NOAA. The APS is not required to remain in the EMOC full time. He may be working on an investigation, but he will be expected to support the POD as necessary. Off-line science analyst(s) will function as assistances to the APS(s). There will be a Science Operations Team on duty twenty-four hours a day, seven days a week.

1.4.2.2 Mission Operations Team

The Mission Operations Team will be composed of the following members:

- o Project Operations Director (POD)
- o System Operators
- o Principal Investigator(s) or their representatives at the ICC(s)

The System Operator(s) will perform the daily on-line functions within the EMOC. The mission operations personnel will implement the short-term schedule under the direction of the POD. During operations, the Eos Mission Team monitors the status of the instruments and the execution of the mission schedule using platform ancillary data and instrument engineering data. In the event of an on-board emergency, the Mission and Science Operations Teams along with the APS will support corrective action.

1.4.2.3 MODIS Instrument Management Team

The MODIS Instrument Management Team (in the MIDACC ICC) will be composed of the following members:

- o Principal Investigator
- o Instrument Engineer(s)

The MODIS Instrument Management Team will monitor the performance of the MODIS instrument, including generation and transmission of commands (real-time and stored), instrument calibration, and quality assessment of the instrument's engineering data. The INstrument Management Team will perform under the direction of the Principal Investigator within the ICC, and include Instrument Engineer(s) who will assist in the evaluation of MODIS engineering data, including evaluation of science quick-look data.

1.5 MIDACC DATA OPERATIONS

Command generation for MODIS will take place in the ICC in conjunction with the PI associated with the MODIS instrument. The commands generated are then forwarded via the EMOC to the PSC as stored commands for future uplink, or, in the case of real-time commands, via the EMOC, directly to the DIF for transmission (please see Figures 1 and 2).

Telemetry data (instrument engineering data, instrument science data, and ancillary data) will be forwarded from the DIF to the DHC for Level 0 processing. Raw ancillary data will also be included for use by ICC and EMOC.

Since processing and data base management is highly distributed, data base administration at the system level will be accomplished at the Information Management Center (IMC). Eos will provide the following functional capabilities:

MIDACC OPERATIONS CONTEXT

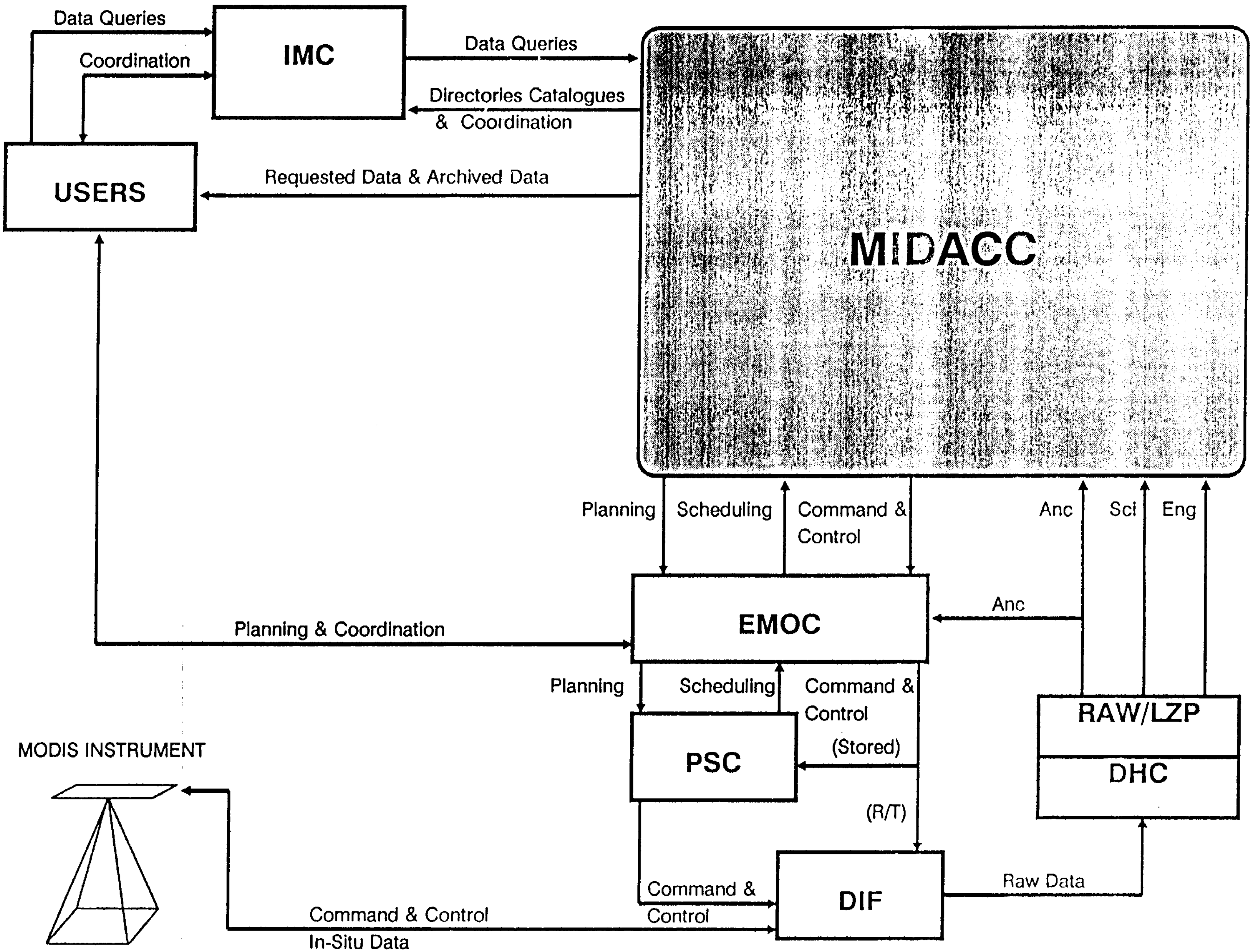


FIGURE 1. MIDACC Operations Context

MIDACC OPERATIONS CONCEPT

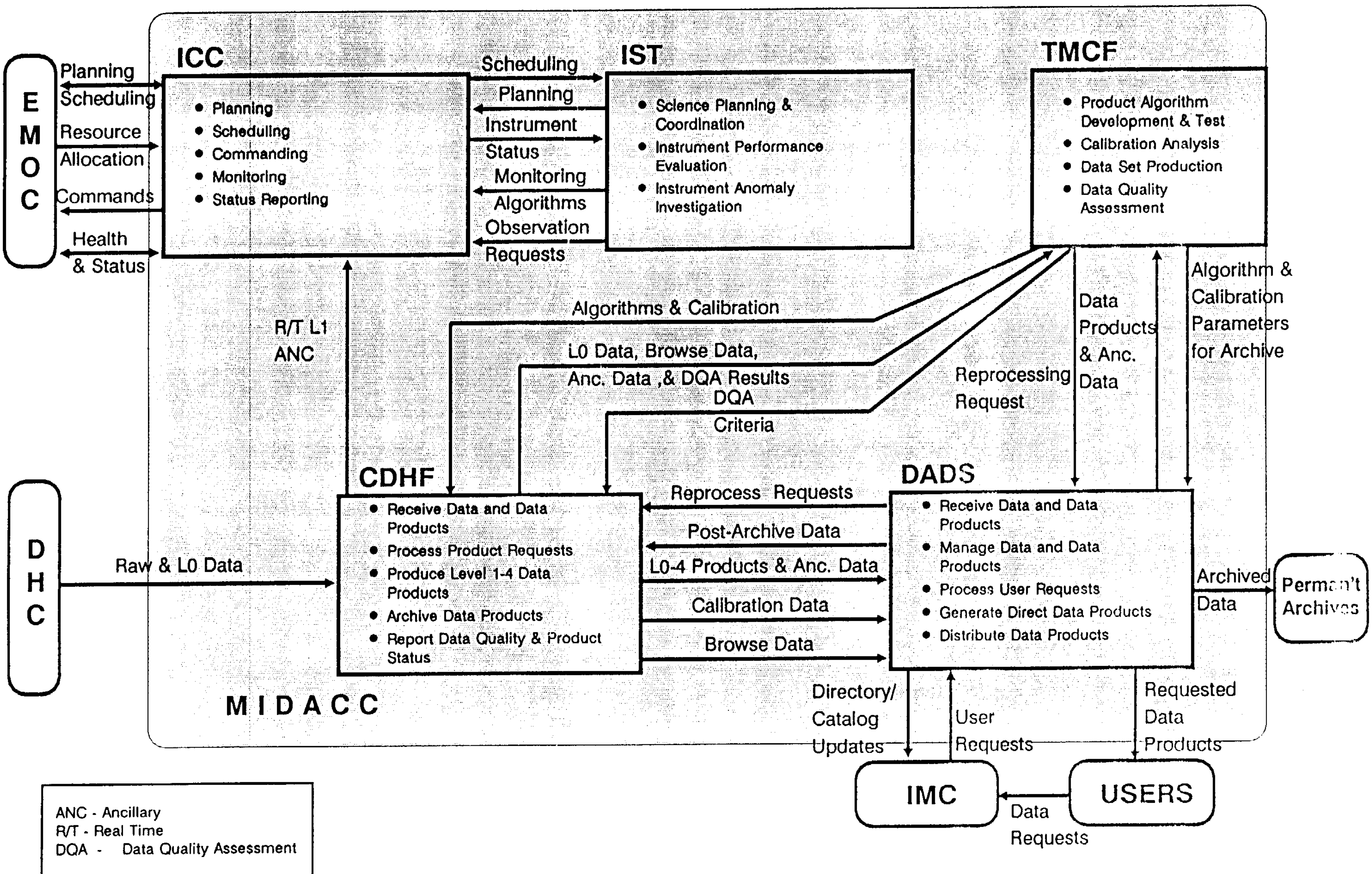


FIGURE 2. MIDACC Operations Concept

- Process, store, and administer all Eos-generated data.

- Establish and maintain a catalog of all Eos-generated data, keyed to engineering and mission parameters, such as time, orbit, geographical location, instrument, spectral band, etc.

- Generate a browse catalog of reduced-volume Eos data containing a summary of each reduced data set as well as key physical attributes.

- Maintain a documentation data base of processing algorithms, and audit trail and mission-related planning information.

- Maintain a data base of user-accessible algorithms which could be used to convert other data bases to Eos format.

- Maintain and control Eos data format standards.

2.0 FUNCTIONAL RESPONSIBILITIES

EosDIS is divided into three areas of functional responsibility--Mission Operations, Instrument Operations and Data Operations. Eos Mission Operations will be provided by the EMOC, MODIS Instrument Operations will be provided by the ICC and IST, and MIDACC Data Operations will be provided by the CDHF and DADS.

2.1 MISSION OPERATIONS

The EMOC will coordinate the operation of Eos instruments on the U.S. platforms and will provide the primary point of contract between the Eos mission and the SSIS for mission operations. Located at GSFC, the EMOC will consist of a project team that includes the POD and the APS.

The EMOC will provide the Eos schedule based on the science plan from the IWG, resource availability received from the PSC, and planning support information from the Flight Dynamics Facility (FDF). According to an agreement between NASA and NOAA, a portion of platform resources is reserved for NOAA. The EMOC will not be responsible for scheduling NOAA operations but will coordinate with NOAA for the scheduling of potentially conflicting operations. The sub-allocations of the remaining resources and guidelines for scheduling will be provided by the EMOC to the ICCs for scheduling instrument operations. The EMOC will receive the schedule requests from the ICCs, resolve conflicts between instruments, and provide a single request for platform resources to the PSC. This process will be iterated until a final conflict-free schedule is distributed to the ICCs. The schedule is then stable but will be able to accommodate perturbations caused by unplanned changes in resource availability, anomalies, and/or Targets of Opportunity (TOO).

The EMOC will monitor operations by processing (and displaying) instrument status information received from the ICCs and the ancillary data received from the DHC. If a safety problem is detected, the EMOC, the PSC or the ICC can send a safing command sequence to the instrument. This will be a coordinated action. The EosDIS will monitor the data distribution systems in order to detect problems in delivering Eos data. Fault isolation will be coordinated with CDOS and other segments of the SSIS.

A log of EMOC operations (including commands received from the ICCs) will be maintained and archived. These archives, coordinated and managed by the EMOC, will be used to support future anomaly analysis and/or science data analysis. The EMOC will provide reports on Eos operations to the Eos project, and it will report the science plan implementation status to the IWG.

2.2 MODIS INSTRUMENT OPERATIONS

The ICC will be responsible for MODIS operations, including the equipment and personnel necessary to plan, schedule, command, and operate the instrument. The ICC will be co-located with the EMOC as GSFC.

The ICC planning process will begin with the receipt of the IWG science plan, platform resource allocations, orbit data, and other guidelines from the EMOC. Within these constraints, the ICC will develop a detailed instrument plan. The MODIS schedule will be submitted to the EMOC by the ICC where it will be iterated to resolve conflicts with other instruments.

Once a schedule is approved, the ICC will generate the detailed MODIS observation schedule including definition of stored command loads necessary for implementation. These commands will be verified by the ICC to ensure the MODIS constraints are not violated and that resource allocations will not be exceeded. The stored commands will then be forwarded to the PSC via the EMOC. Updates to these commands may be required for unanticipated schedule changes (i.e., due to a TOO or an anomaly). Real-time commands will be forwarded by the ICC via the EMOC to the DIF to react to an anomaly or to make real-time adjustments to the instrument.

MODIS operations will be monitored in the ICC by processing and displaying instrument engineering data and ancillary data. Proper execution of the commands will also be verified at the ICC. Status data will be provided by the ICC to the EMOC as required. The ICC will also perform quick-look analysis of science data when required to support instrument operations.

The ICC will maintain historical data of MODIS operations, including instrument engineering data, commands, and other significant events. The ICC may be required to perform off-line analysis of these historical data. These data will be archived in the vent further analysis is required.

The MODIS IST (not co-located with the ICC) will be used by the Team Leader to remotely access the ICC. Potential IST functions include monitoring MODIS operations, investigating anomalies, defining procedures, updating instrument parameters and software, and submitting command requests.

2.3 MIDACC DATA OPERATIONS

The production, short-term storage, and dissemination of scientifically useful data sets from MODIS will be performed by the Active Archives and Team Member Computing Facilities. The production, initial archiving and distribution of Level 1 and higher data from MODIS will be done in EosDIS Active ARchives, which include the MIDACC CDHF and DADS facilities. The CDHF will process Level 0 data from MODIS into Level 1-4 data products using algorithms provided by the MODIS Instrument Team. The DADS facilities will store MODIS data sets for limited periods of time, provide remote and local access to the data, and distribute data to users and to the Permanent Archives.

PROPOSED OUTLINE FOR SECTION 3 OF FUNCTIONAL REQUIREMENTS DOC.:

3. FUNCTIONAL REQUIREMENTS

3.1 INSTRUMENT CONTROL CENTER (ICC)
- 3.1.1 Operations planning and scheduling
  - 3.1.1.1 Receive Science Plan and Instrument Resources
  - 3.1.1.2 Receive Observation Request
  - 3.1.1.3 Verify Observation Request
  - 3.1.1.4 Generate Schedule Request
  - 3.1.1.5 Coordinate Schedule
- 3.1.2 Instrument command generation
  - 3.1.2.1 Receive Command Request
  - 3.1.2.2 Verify Command Request
  - 3.1.2.3 Generate Stored Commands
  - 3.1.2.4 Generate Real-Time Commands
  - 3.1.2.5 Send Commands to EMOC
  - 3.1.2.6 Send Commands to CDA
  - 3.1.2.7 Receive Execution of Commands
  - 3.1.2.8 Verify Execution of Commands
- 3.1.3 Instrument monitoring
  - 3.1.3.1 Receive Data
  - 3.1.3.2 Verify Instrument Health and Safety
  - 3.1.3.3 Verify Instrument Performance
- 3.1.4 Instrument status tracking
- 3.1.5 Training and Tests
  - 3.1.5.1 Train Personnel
  - 3.1.5.2 Support Simulations
- 3.1.6 Interfaces
  - 3.1.6.1 Interface to DADS
  - 3.1.6.2 Interface to IST
  - 3.1.6.3 Interface to TMCF
  - 3.1.6.4 Interface to CDHF

3.2 INSTRUMENT SUPPORT TERMINAL (IST)
- 3.2.1 Operations planning
- 3.2.2 Operations scheduling
- 3.2.3 Instrument monitoring
- 3.2.4 Interfaces

3.3 TEAM MEMBER COMPUTING FACILITIES (TMCF)
- 3.3.1 Calibration support
  - 3.3.1.1 Instrument monitoring
  - 3.3.1.2 Instrument analysis and scheduling requests
  - 3.3.1.3 User assistance
  - 3.3.1.4 Calibration data distribution
- 3.3.2 Scientific algorithm support
  - 3.3.2.1 Development and verification
  - 3.3.2.2 Maintenance
  - 3.3.2.3 Documentation
- 3.3.3 Production of data sets
- 3.3.4 Data quality assessment
- 3.3.5 Interfaces

3.4 CENTRAL DATA HANDLING FACILITY (CDHF)
- 3.4.1 Standard data products production
  - 3.4.1.1 Level 1 data products
  - 3.4.1.2 Level 2 data products
  - 3.4.1.3 Level 3 data products

ACTION ITEMS:

7/8-2 (Sharts) Investigate the effect, if any, that real-time and possibly redundant data transmissions will play in determining the MODIS data rates and volume. ** Closed **

7/8-3 (Han) Review the draft data product questionnaire with members of the MODIS Instrument Team. ** Sent out for comment **

7/15-1 (Han) Confirm the 10 and 20 megabit per second data rates projected for low data-rate instruments and the platform LAN.

7/29-1 (McKay) Fully analyze the scope and implications of the following EosDIS resource bottlenecks with respect to the MODIS data system: communications link between ground and platform, on- board LAN, on-board mass storage, and on-board processor.

7/29-2 (McKay) Describe in detail the differences between real- time, priority playback, and routine data with regards to treat- ment and priorities in the DHC and DIF.